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PHYSICS AT E0 FOR THE 1991-92 COLLIDER RUN, a proposal

Spokesperson:

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Introduction

Some of the experimenters of E710 along with some others would like to do some new physics at E0 using a new generation of detector at the E0 pot positions. The E710 data analysis is now far enough along to show that it has achieved the goals stated in its proposal. Significant rises in σ_t, B, and especially σ_{el} have been measured independent of luminosity.[1,2,3,4] As stated in its proposal, the E710 detector design was such that it could not measure ρ at the full energy of $\sqrt{s}= 1.8$ TeV. (This is further demonstrated in Section I of Appendix I.) However, E710 had runs at $\sqrt{s} = 546$ and 1000 GeV which will soon give determinations of ρ more accurate than that of UA4.

If one accepts the UA4 value of ρ, it appears to be rising much faster than σ_t. Both UA4 and E710 have confirmed that σ_{el} is rising significantly faster than σ_t. E710 has found that the slope parameter B no longer decreases with increasing angle, at least up to $-t\sim 0.5$ GeV^2. The only way to resolve these mysteries is to measure ρ at the full energy and $d\sigma/dt$ at larger angles. Our goals are threefold: (1) to do some new physics which was not obtainable in the last run, (2) to develop and fully test a new-generation small angle detector

for the LHC and SSC, and (3) to give an accurate and reliable calibration of the Tevatron luminosity.

Goals

1. An accurate measurement of ρ at $\sqrt{s}$ = 1.8 TeV.

2. A luminosity independent accurate measurement of σ_t at $\sqrt{s}$ = 1.8 TeV. (Our new detector will have adequate resolution and acceptance to measure $d\sigma/dt$ in the "pure" coulomb region. See Appendix I.)

3. Large angle $d\sigma/dt$ in the region $0.4 < -t < 3$ GeV^2 (using collisions at B0).

4. Single diffractive (using collisions at D0 and D0 detector).

5. To develop a detector and the technology for doing the same physics at the SSC and LHC. (The best test of a new detector is to do some new physics with it.)

6. To improve the present Tevatron collider luminosity calibrations by an order of magnitude.

Equipment

Everything would be the same as in E710 except that the drift chambers in the pots would be replaced by scintillating fiber detectors using CCD readout. In the design of E710 we estimated on the basis of ISR results and predicted emittance that our detector could not get closer than ~5 mm from the beam and that a resolution ~1 mm would be adequate; in fact we stated in the proposal that we could not get into the coulomb region at the full energy. But, in the running of E710, after proper scraping, we found a factor ~5 improvement in emittance and we learned that high resolution detectors would work

closer than 2 mm from the beam. We measured that the emittance spread at the detector after scraping was 0.3 mm or less rather than 1.2 mm. The observed time constant for emittance growth was significantly more than 1 hour. These new conditions along with a newly designed detector will make possible the measurement of ρ at $\sqrt{s}$ = 1.8 TeV. (See Section II of Appendix I.) So we now have underway the design and construction of a scintillating fiber detector with 0.2 mm diameter fibers.

Some of the early concepts of this new detector were developed at the 1988 Berkeley SSC Summer Workshop with the help of Riccardo DeSalvo.[5] See Figure in Appendix II. At present we have a group of about 3 physicists working on this at CERN under the direct supervision of DeSalvo. Most of the components such as SCIFI bundles, fiber optic "cables" and windows, image intensifier stages, ccd's, ccd readout software and hardware will be produced by private firms such as Kyowa Gas, Hamamatsu, Datacube, DEP, Phillips, and Thompson. We have access to CERN facilities such as an aluminum sputtering rig, the ccd readout and encoding system, test beams, vacuum testing rig, etc. CERN also regards this effort as part of their development program of a small angle detector system for the LHC.

The new detectors are designed to "hang" in the vacuum from the end plates of the existing roman pots. The E710 cables, electronics, computers, and trailers are still in place and would be reused. Some of the exisiting ring counters would be reused.

Resources and Manpower

The SCIFI detectors are now being designed and constructed and will be tested in test beams and hard vacuum at CERN by Rosy

Mondardini and Cinzia Davia under the supervision of Riccardo DeSalvo, Tiziano Camporesi and Jay Orear. Our initial group of collaborators are from CERN, Cornell University, Fermilab, and the University of Bologna. The present spokesperson is Jay Orear of the Cornell University users group.

Beam Requirements

The 900 GeV running for σ_t and ρ will require special scraping and running with the separators off. The previous running conditions would be very adequate. The ccd's are limited to a master trigger rate ~ 60 Hz which is comparable to our tape writing speed. Our goal is to obtain several hundred thousand elastic events. This will only take a few hours of running. It would be useful for other experiments to at least turn on their luminosity monitors during our several hour "dedicated" run, since we would be measuring E0 luminosity in an accurate way independent of the usual uncertainties. A comfortable luminosity for this dedicated run is ~10^{28} $cm^{-2}s^{-1}$ at E0.

The large-angle elastic and single-diffractive data collection will be purely parasitic and will not affect the running at B0 and D0. The scheme for parasitic running was studied at the Breckenridge workshop. The relevant part of the Breckenridge report is quoted in Appendix II. Norman Amos of the D0 group would act as liason between the D0 group and our group. Stan Pruss and Norman Gelfand will provide accelerator liason.

Footnotes:

1. Amos, et al, Phys. Rev. Letters 61, 525 (1988).

2. Amos, et al, Phys. Rev. Letters <u>63</u>, 2784 (1989).

3. Amos, et al, *A luminosity independent measurement of the $\bar{p}p$ total cross section at $\sqrt{s}$= 1.8 TeV*, submitted to Physics Letters.

4. Amos, et al, *Measurement of large angle $\bar{p}p$ elastic scattering at $\sqrt{s}$= 1.8 TeV*, submitted to Physics Letters.

5. Goulianos, et al, *Low p_t physics at the SSC*, p. 828, "Experiments, detectors and experimental areas for the supercollider", World Scientific Publishing Co. 1988, ISBN 9971-5-473-1.

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J. Orear.

CAN WE GET ρ FROM EXISTING DATA AT 900 GEV?

and

CAN WE GET ρ FROM NEW DETECTORS AT 900 GEV?

Section I: The Present Detectors

In the low-t running at 900 GeV we did get our pots close enough to the beam to see elastic scatters in the region where the coulomb amplitude equals the nuclear amplitude. Unfortunately the solid angle at low-t was small because x is increasing fast with x as well as y and the x region is limited at small y. In this memo I shall do a statistical analysis showing that we can get only an upper limit on ρ.

We might be able to get a luminosity independent σ_t based on coulomb normalization, but it would be no better than what we have already obtained. In Section II I shall show that a scintillating fiber (SCIFI) detector should be able to get good determinations of ρ and σ_t. $^{\text{L}_{eff}}_{\sigma_t^{L_{eff}}}$ I shall make the following rather optimistic assumptions: there is no error to the background subtraction and we can get data with adequate t-resolution in the low-t bins with little loss correction. Shekhar points out that this assumption is overly optimistic because on some wires our scale factor is 1 mm/bit. It is never better than 0.5mm/bit. I also assume we know the beam center in x for each wire. But it might be off by ~1 bit or ~ 1mm. In some regions of my bins 1, 2, and 3 the separation in x is only ~0.4 mm which is smaller than our least count. But I feel that if we cannot determine ρ with these optimistic assumptions, then we certainly cannot measure ρ if the true situation is even worse; i.e., there is no way can do better with the existing data. [1] In my calculation I use true $\rho = 0.1$, $(L_{eff})_y = 80$ m and $(L_{eff})_x = 40$ m. The bins I use are shown in Fig. 1 and tabulated in Table I. I use true $\sigma_t = 80$ mb. The differential cross section is

$$\left[\frac{d\sigma}{dt}\right]_j = .0513 \left\{\sigma_t^2(1+\rho^2) + \frac{.1424\rho}{t_j}\sigma_t + \frac{5.07 \times 10^{-3}}{t_j^2}\right\} \text{ mb/GeV}^2 \equiv F_j(\rho,\sigma_t)$$

where σ_t is in mb and t is in GeV^2. In order to simplify the calculation, I have used $\exp(-Bt) = 1$ in this low t region. (This is OK as long as we have an independent sufficiently accurate

determination of B which is the case.) The expected number of events in the jth bin is

$$\bar{N}_j = L\left[\frac{d\sigma}{dt}\right]_j A_j \qquad \text{where } L = 4.5 \times 10^{30} \text{ cm}^{-2} \text{ is the integrated lum-}$$

inosity and $A = \Delta t \, \Delta\phi_j/2\pi$. (This value of L gives 40,000 elastics in the region $.01< t < .09$ GeV^2 as in our data.) These events are given statistical fluctuations of $\sqrt{\bar{N}_j}$ and the least squares sum S is evaluated as a function of L, ρ and σ_t:

$$S = \sum_j \left[\frac{L F_j A_j - \bar{N}_j}{\sqrt{\bar{N}_j}}\right]^2 \qquad \text{(Eq. 1)}$$

The solution for the ρ, σ_t, and L which minimize S corresponds closely to the starting values giving $S^* = 9.5$. Then I found the 3D "ellipsoid" corresponding to $S(L,\rho,\sigma) = S^*+1$. As might be expected, the errors in L and σ_t are highly correlated. The correlations are properly taken into account if one finds the extreme excursions the surface makes along the ρ-axis. [2] They are $0.05 < \rho < 0.19$. The one standard deviation determination on σ_t was $74 < \sigma_t < 87$ mb or $\sigma_t = 80.5 \pm 6.5$. This is without using any information on the accelerator measurement of L. If we have such information using our calibrated monitor, then a term $(L-L^*)^2/\Delta L^2$ should be added to Eq. 1 where L* is the measured value of L with error ΔL. But in this analysis I did not include such a term — I wanted to see what coulomb amplitude normalization would do for us all by itself. By coincidence it also gave us a 8% error.

So I conclude that if the true $\rho=0.1$, we can only say that $\rho<0.2$ and that we cannot use coulomb normalization by itself to improve our measurement of σ_t. The situation is probably worse than this because of error in background subtraction and because of Footnote 1. It is still worth analysing our 900 GeV low-t data in order to make these checks, but as I have just shown, we will not get any new results out of it except for a crude upper limit on ρ.

Section II: New Detectors

In order to measure ρ at 900 GeV and to get an accurate, reliable

preprint CLNS 82-511. (I do have a proof.)

measurement of σ_t using coulomb normalization, we need detectors with resolution better than 300μ in both x and y. (300μ is the measured "emittance limit" at our detector position after scraping.) In the last run we have discovered how to get detectors within 2.2 mm of the beam, but then there is some bothersome halo-halo background. With the present drift chamber detectors, halo particles with y< 3 mm and x within 2 mm of beam center all end up in the same bin. But if we had an x-resolution ten times better, we could perhaps reduce this background by an order of magnitude. A detector using a bundle of 200μ diameter scintillating .ibers should be able to meet these conditions. This memo will not deal with construction and performance details. In this memo we assume the background free bins shown in Fig. 2 and Table II. We shall repeat the above least squares analysis assuming a total of 100K elastics in these bins (this corresponds to an integrated luminosity of $L=4.5\times10^{31}$ cm^{-2}). My least squares solutions to the simulated data in Table II is $\rho = 0.090\pm0.022$ and $\sigma_t = 79.9\pm1.1$ mb starting with "true" values $\rho=0.1$ and $\sigma_t = 80$ mb. The total cross section is obtained only from coulomb normalization.

Note in Fig. 2 that bin 1 and part of bin 2 gets closer than 2 mm from the beam. I am guessing that we can get our detector edge 1.75 mm from the beam. However, we know from the last run that we can at least get to ±2 mm from the beam. I have repeated the analysis for this more pessimistic assumption; i.e., bin 1 and half of bin 2 are eliminated. Then my solution is $\rho = 0.093\pm .035$ and $\sigma_t=79.9\pm2.1$ mb. ...en in this pessimistic case we get a ρ-value more accurate than UA4 and a luminosity independent measure of σ_t of about 2%.

Footnotes:

1. Shekhar also points out that the *charge division* smearing in x is so bad that to be safe one should do an x-independent analysis. I have not yet done this, but it will give larger errors on ρ and σ_t than what I have obtained.

2. J. Orear, "Notes on Statistics for Physicists", page 46, Cornell

Table I: Bins for existing detector in low-t runs.

bin no.	t_j (Gev⁴)	A_j (Gev⁴)	N_j
1	1.36×10^{-3}	$.889\times10^{-4}$	220
2	1.79	1.12	209
3	2.25	3.57	659
4	3.82	4.59	726
5	5.3	5.18	1010
6	7.2	7.4	1114
7	9.1	8.79	1386
8	11.4	10.1	1500
9	18.7	51.3	7832
10	37.4	80.2	11915

Table II: Bins for proposed detector.

bin no.	t_j	A_j	N_j
1	$.445\times10^{-3}$	$.317\times10^{-4}$	2584
2	.641	.665	3103
3	.957	1.08	3345
4	1.34	1.48	3405
5	1.78	1.72	3514
6	2.55	5.62	9870
7	3.82	6.55	10854
8	5.3	8.02	12587
9	7.2	9.13	14282
10	9.1	10.4	15840
11	11.4	11.6	17814

ELASTIC AND SINGLE DIFFRACTIVE SCATTERING

Sections 1 and 2 deal with small and large angle elastic scattering using detectors at E0. An accurate luminosity-independent determination of σ_t and ρ would be made. Section 3 treats single diffractive scattering using detectors at D0 and E0.

1. Small angle elastic (σ_t and ρ-value)

If the elastically scattered proton and antiproton can be detected at very small angles (in the coulomb region), the luminosity and total cross section can be determined to within 1 or 2%. The ρ-value is determined by the amount of coulomb interference. E710 in the last run was not quite able to reach the coulomb region because of detector wall thickness and resolution. An improved detector with zero wall thickness and order of magnitude improvement in resolution is now in the design and prototype construction stage. As shown in Fig. 1 , it would use a scintillating fiber bundle attached to the existing Roman Pots in the E0 region. The fibers would be oriented parallel to the beam. A short run under high beta with special beam scraping would be needed. The conditions used by E710 in the last run would be adequate. Not only would the new detectors give accurate values for σ_t and ρ, but they would give an accurate and independent calibration of luminosity. About one day of running using the fixed target lattice would be needed. At the same time B0 and D0 could run under interesting high beta conditions.

2. Large angle elastic scattering

The SCIFI detectors of Fig. 1 could be used in a parasitic mode under normal low beta running conditions when the beams are separated
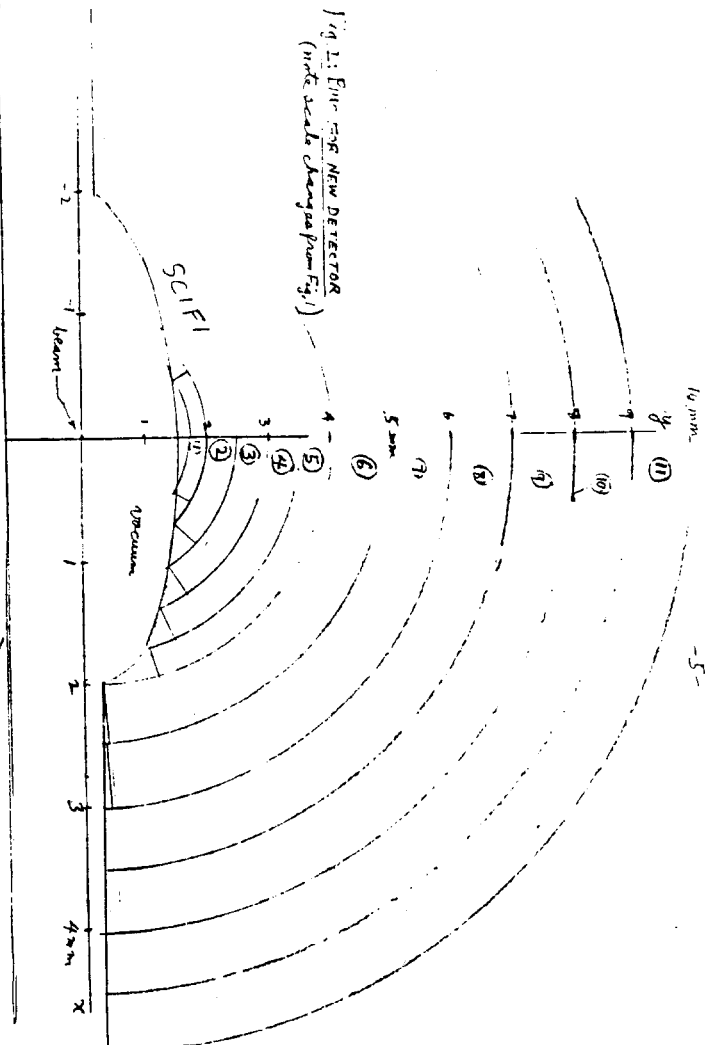

Fig 1: Bins for NEW DETECTOR
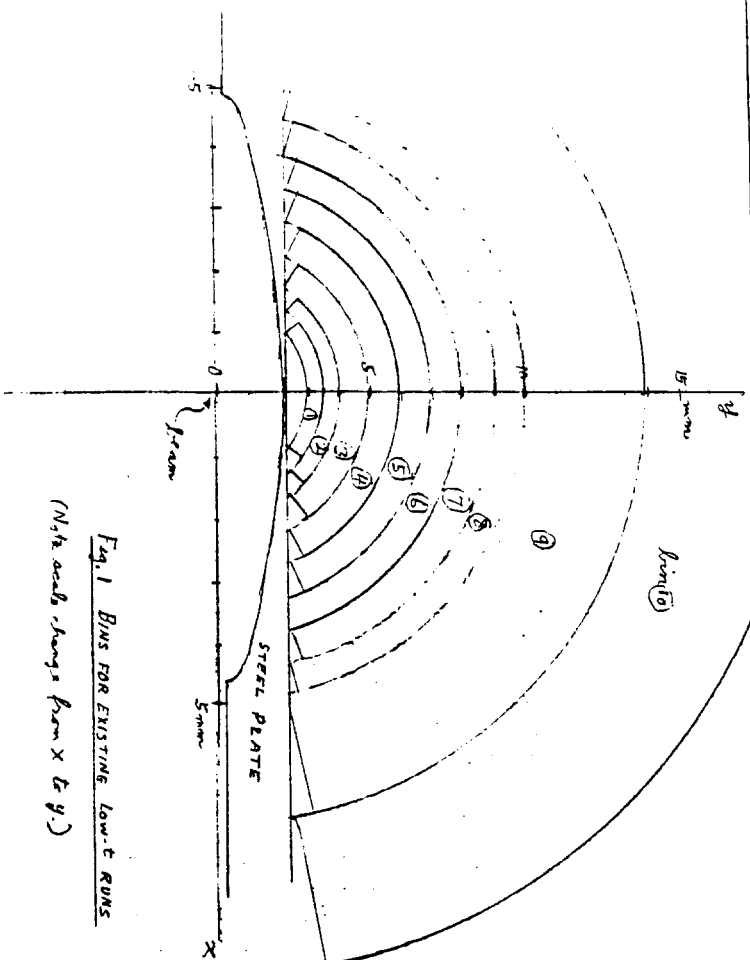(note scale change from Fig. 1)

Fig. 1 BINS FOR EXISTING Low-t RUNS

(Note scale change from x to y.)

at E0. For large angle elastic scattering at B0 or D0 both the scattered proton and antiproton will be seen in some of the E0 detectors. There are two inner detectors (at ends of the long straight section) and two outer detectors "buried" in the lattice. From B0 to the left-outer detector the vertical L-effective is 6.59 m. Assuming the detector can get within 4 mm of the beam (in E710 the old detectors could operate as close as 2.2 mm from the beam), the minimum scattering angle would be 4 mm/6.59 m = 0.6 mrad or t_{min}= 0.3 Gev². The antiproton would encounter the right-outer detector with L_y = -6.57 m. If the fiber bundle is 15 mm thick, t_{max}= 6.8 Gev².

For elastics from D0 the situation is similar except that the L-effectives are about 20% shorter. The difference in arrival time would be 2/3 of the circumference. Electronic delay could be used on the trigger.

3. Single diffractive scattering

The scattered proton from single diffractive scattering at B0 or D0 can make it to the E0 detectors in an interesting region of t and M^2. (0<-t< 4 Gev² and 1.4< M < 150 Gev .) In order to be well within the diffraction peak it would be necessary to rotate the Roman Pots from the vertical to the horizontal.
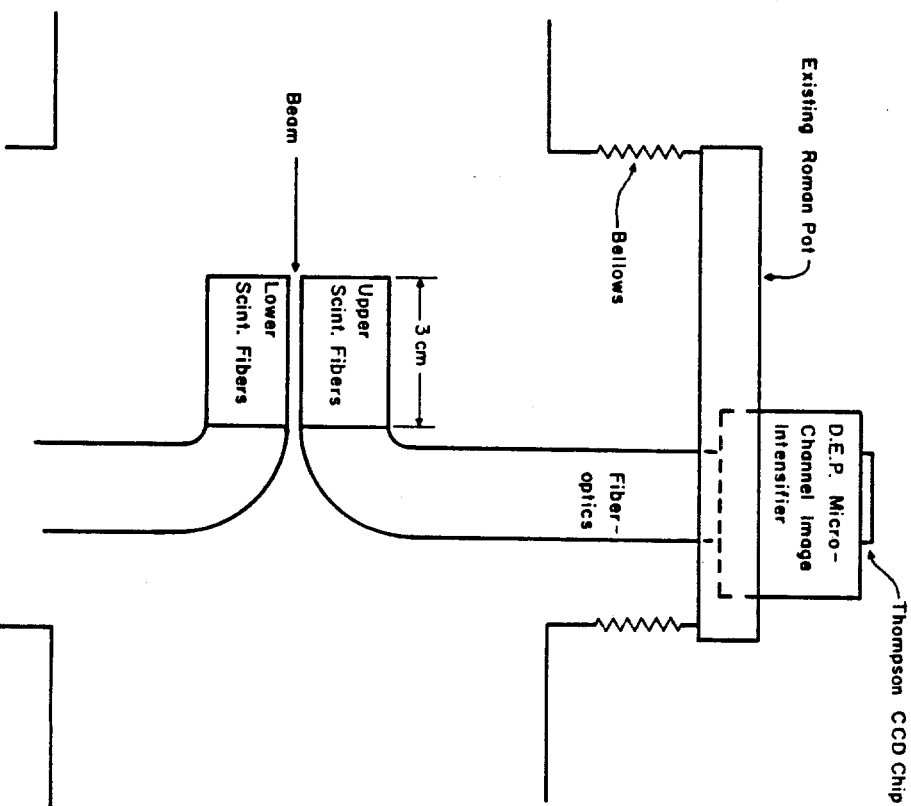
In principle both the scattering angle and momentum (or t and M) can be determined from two sets of (x,y) measurements; i.e., two detectors near E0). In order to reduce possible background a third detector would provide two more over-determinations. In the last run E710 did a two detector short run on single diffractives and found a strong, clean signal.

Even though scatterings corresponding to low M would be seen in the detectors, only values of M greater than 10 Gev could be resolved. This is because Δp/p due to measuring resolution and beam momentum spread is ~2x10⁻⁵.

It is of great interest to see the entire event -- the M-decay as well as the scattered hadron. The "4π" detector of D0 which gets to higher rapidity might be well-suited for this. Some fraction of

their triggers will be random. Of these ~10% will send diffractively scattered protons into the E0 detectors. At E0 only those bunches selected by D0 for "random" triggers would be looked at.

Depending on the polarity of the electrostatic separators, the antiproton beam could be at smaller x than the proton beam at the E0 detectors. This would prevent the E0 pots from getting close enough to the proton beam. Since the polarity of the separator system is arbitrary, one choses the polarity which puts the antiproton beam on the far side.

Existing Roman Pot

Bellows

D.E.P. Micro-Channel Image Intensifier

Fiber-optics

Thompson CCD Chip

Beam

Upper Scint. Fibers

Lower Scint. Fibers

3 cm

Modification of Roman Pots for Tevatron

FERMILAB-Proposal-0811

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PHYSICS AT E0 FOR THE 1991-92 COLLIDER RUN

Fermilab Proposal 811

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Introduction

Some of the experimenters from E710 along with others would like to do some new physics at E0 using an innovative small angle detector at the E0 pot positions which can exploit the large improvement in Tevatron emittance which was obtained during

E710 beam scraping. The E710 data analysis has shown that the method of inserting small angle detectors into the magnet lattice works quite well. E710 was able to measure the L-effectives and their ratios to ~1% by two different methods. The measured values agreed with the calculated values. Four papers from E710 have been published and one is in preparation.[1,2,3,4,5] We expect at least a sixth paper on ρ-values and then a detailed, comprehensive paper for Phys. Rev. D. Significant rises in σ_t, B, σ_{sd} and especially σ_{el} have been measured using luminosity independent methods.[1,2,3,5] As stated in its proposal, the E710 detector design was such that it could not reach the coulomb region at the full energy of √s= 1.8 TeV. The E710 ρ-analysis at this energy is near completion and indicates a preliminary value of 0.19±0.08. Unfortunately the error on ρ is too large to settle the question of the unusually large ρ-value seen by UA4.[6] There is more information on ρ to come from the E710 runs at √s = 300, 546, and 1020 GeV.

If ρ really is as large as 0.24 at √s = 546 GeV, then some hind of new physics is needed. In order to help determine what that new physics is (or whether the UA$ result is wrong), an accurate measure of ρ at the highest possible energy is needed. A primary goal of this proposed experiment is to measure ρ with an accuracy of ±0.009 at √s = 1800 GeV.

Major Goals

1. An accurate measurement of ρ at √s = 1.8 TeV.

2. A different and more accurate determination of σ_t at $\sqrt{s}$ = 1.8 TeV based on measurement of the coulomb amplitude. (This will be independent of luminosity and inelastic rate information. Our new detector will have adequate resolution and acceptance to measure $d\sigma/dt$ well into the coulomb region. It can definitely measure $d\sigma/dt$ 2.5 mm from the beam where the coulomb cross section is 60% greater than the nuclear.)

3. To develop a detector and the technology for doing the same physics at the SSC and LHC. (The best test of a new detector is to do some real physics with it.)

4. To improve the present Tevatron collider luminosity calibrations by an order of magnitude. (The ratio of coulomb events to the coulomb cross section should give a determination of luminosity better than 1%. This will be compared with the usual method of luminosity measurement. A flying wire at E0 will help in making the comparison.)

Equipment

The layout will be similar to that in E710 except that the drift chambers in the pots (and the pots themselves) would be replaced by scintillating fiber detectors using CCD readout. In the design of E710 we estimated on the basis of ISR results and predicted emittance that our detector could not get closer than ~5 mm from the beam and that a measuring resolution ~1 mm would be adequate; in fact we stated in the proposal that we could not get into the coulomb region at the full energy. But, in the running of E710, after proper scraping, we found a factor ~4 decrease in emittance and we learned

that high resolution detectors would work as close as 2 mm from the beam. We measured that the resolution smearing at the detector was 1.2 mm before scraping and 0.3 mm after scraping. The observed time constant for emittance growth was significantly more than 1 hour. These new conditions along with a newly designed detector will make possible an accurate measurement of ρ at $\sqrt{s} = 1.8$ TeV. In pursuit of this goal we have completed the design and construction of a scintillating fiber detector with 0.1 mm diameter fibers.

Some of the early concepts of this new detector were developed at the 1988 Berkeley SSC Summer Workshop with the help of Riccardo DeSalvo.[7] The detector is shown in Fig. 1. We have two physicists, Mondardini and Da Via working full-time on this at CERN under the direct supervision of DeSalvo. SCIFI bundles have been built by Kuraray Co., Ltd of Tokyo and have passed high vacuum tests for outgassing. (After 5 days of pumping the test bundle reached a pressure of 10^{-8}, and 10^{-9} after 10 more days.) The electro-optic readout chain (2 stage, microchannel image intensifiers model XX1450 by DEP of Holland) is designed to give 100% efficiency for a single photoelectron. Any track passing through the 50 mm of scintillating fiber will give an average of ~25 photoelectrons. So the fast pulses from the final anode should correspond to those of a 100% efficient scintillation counter. As a check, this efficiency will be monitored by the two scintillation counters, S1 and S2. Single, double, and triple coincidence combinations will give redundant efficiencies of all three. The second phosphor is coupled by a fiber optics taper to a Phillips NXA1011 ccd chip which is digitized by a Data Translation DT 2255 image processing board in a

MacII computer. At present the complete instrument is under optical and radioactive source tests. These tests have already shown that the spatial resolution is ~40 μm in both x and y. The detector will soon be moved to a CERN test beam.

The new detectors are designed to "hang" in the vacuum from new end plates which fasten to the existing Roman Pot positioning system. Maximum dead space between beam pipe vacuum and full sensitivity will be 50μ. (The previous detector could not get closer than 2.2 mm from the beam.) The E710 cables, electronics, computers, and trailers are still in place and would be reused. Some of the exisiting ring counters would be reused.

Beam Requirements

The 900 GeV data taking for σ_t and ρ will require special scraping and running with the separators off. The previous running conditions would be very adequate. Fig. 2 gives some idea of the cleanliness of beam that was obtained. This is the small-y corner of the y_{left} vs y_{right} plot for run 758. No background has been subtracted. It is clear that the y-resolution obtained is close to 300 μm and that the background is essentially zero everywhere except within 5 mm of the beam. Even at 2.5 mm from the beam the background subtraction is less than 40%.

The ccd's are limited to a master trigger rate ~ 60 Hz which is comparable to our tape writing speed. Our goal is to obtain several hundred thousand elastic events. We know from E710 that it is easy to collect 10 good elastics per second. Ten hours of this would yield 360,000 events. It would be useful for other experiments to at least

turn on their luminosity monitors during our several hour "dedicated" run, since we would be measuring E0 luminosity in an accurate way independent of the usual uncertainties. A comfortable luminosity for this dedicated run is $\sim 10^{28}$ cm^{-2}s^{-1} at E0. Then continuous running of ~ 10 hours would accumulate the desired statistics. The experience with E710 was that ~ 3 days of running were scheduled in order to achieve a successful dedicated run. (Much of the 3 days was used in scraping studies.) The equipment will be well tested and in good working order by using beam halo as a "test beam" during B0 and D0 running. Another class of testing would be on E0 collisions. For this we would recommend "normal" B0 and D0 running, but with the electrostatic separators turned off (this might at times result in some reduction of luminosity). We estimate up to a total of 2 weeks of testing when the separators are off. It may be that over the entire running period that the separators would be off for such an amount of time. In summary we estimate up to 2 weeks of testing when the separators are off and ~ 1 week of dedicated running with our special beam scraping.

Anticipated Results

The experiment will be quite successful if our lowest-t bin centers on 2.8 mm from the beam. One wonders why was E710 essentially unsuccessful in measuring ρ when their detector was 2.2 mm from the beam? The main reason was inability to obtain x-coordinates of sufficient reliability from charge division. The edges of the trigger counters at ±14 mm did provide reliable x-values. So the lowest t bin was a strip 3.0 to 3.25 mm from the beam in y, but ±14 mm in x. This strip covered a t-range from

1.24×10^{-3} to 70×10^{-3} GeV^2. Such a strip would have only ~4% more events when $\rho = .15$ than when $\rho = 0$.

With the new detector and reliable x-measurements to ~50 μm one could have, for example, the lowest t bin be y=2.8±.5 mm and x=0±.25mm (t = 10^{-3} GeV^2). (y= 2.2 mm which is still quite reasonable would give t = 0.6×10^{-3} GeV^2.) At y = 2.8 mm $\rho = .15$ would contribute an extra 28% in the coulomb interference region. If there were just 5 equal-sized bins from t=10^{-3} to t=5×10^{-3} each with 1% error (equivalent to a total of 50,000 events in this region) the error on the ρ-determination would be 8.7×10^{-3} which is an order of magnitude better than that obtained by E710. Ten hours of continuous running at a luminosity of 10^{28} cm^{-2}s^{-1} would give this amount of statistical accuracy.

The ultimate limit on closeness to the beam is determined by the size of the background subtraction. In E710 the limit of y= 2.2 mm was determined by the thickness of the detectors and not by the background rate. In our best runs the background subtraction was about 40% at y= 2.5 mm. Such a background was accurately determined and hardly contributed to the error on ρ. This was the background after making a y-y cut (cutting on the diagonal in Fig. 2). This cut reduced the background by about a factor of 3. E710 did not make a x-x cut. With the new detector we can make an x-x cut; we estimate that this x-x cut should reduce the background by another factor of 3. With all these factors in our favor, it is almost certain that this experiment will reach the coulomb region as long as the beam quality is the same as was measured in E710.

Parasitic Running

The new detectors could be used in a parasitic mode under normal low beta running conditions when the beams are separated at E0. In this mode it should be possible as a fringe benefit to obtain some new physics as well. We discuss obtaining data on large angle elastic scattering from collisions at B0 and single diffraction from interactions at D0.

For large angle elastic scattering at B0 both the scattered proton and antiproton will be seen in some of the E0 detectors. From B0 to the left outer detector the vertical L-effective is 6.59 m. Placing the detector at y_{min} = 4 mm, the minimum scattering angle would be 4 mm/6.59 m = 0.6 mrad which corresponds to t_{min}=0.3 GeV^2. The antiproton would encounter the right outer detector with L_y=-6.57 m. Since the top of the fiber bundle would be 14 mm from the beam, t_{max}= 3.6 GeV^2.

The scattered proton from single diffractive scattering at D0 can make it to the E0 detectors in an interesting region of t and M^2 (0<-t< 4 GeV^2 and 1.4<M< 150 GeV). In order to be well within the diffractive peak it would be necessary to rotate the Roman Pots from the vertical to the horizontal. In principle both the scattering angle and momentum (or t and M) can be determined from two sets of (x,y) measurements, i.e., two detectors near E0. In order to reduce possible background, a third detector would provide two more over-determinations. In the last run E710 did a two-detector run on single diffractives and found a strong signal with less than 1% background.

Even though scatterings corresponding to low M would be seen in the detectors, only values of M greater than 10 GeV could be resolved. This is because $\Delta p/p$ of the beam is $\sim 2 \times 10^{-5}$. It is of great interest to see the entire event -- the M-decay as well as the scattered hadron. The "4π" detector of D0 which gets to high rapidity should be well suited for this. A few percent of their minimum bias triggers will send diffractively scattered protons into the E0 detectors. Depending on the polarity of the electrostatic separators, the antiproton beam could be at smaller x than the proton beam at a given E0 detector. This would prevent the E0 pots from getting close enough to the proton beam. Since the polarity of the separator system is arbitrary, one chooses the polarity which puts the antiproton beam on the far side. We would store information from each proton bunch crossing in the ccd's. If both the local trigger and a level 1 trigger from D0 are obtained, then the ccd information is read out; otherwise the ccd is cleared after $\sim 7\mu s$ in time for the next bunch. (The time to generate the D0 trigger is significantly less than the 7 μs.)

Footnotes:

1. Amos, et al, Phys. Rev. Letters 61, 525 (1988).

2. Amos, et al, Phys. Rev. Letters 63, 2784 (1989).

3. Amos, et al, Physics Lett. B243, 158 (1990).

4. Amos, et al, Physics Lett. B247, 127 (1990).

5. Amos, et al, *Measurement of p̄p → p̄+X at √s = 1.8 TeV*, paper in preparation.

6. UA4Collab., D. Bernard et al, Physics Lett. B198, 583 (1987).

7. Goulianos, et al, *Low p_t physics at the SSC*, p. 828, "Experiments, detectors and experimental areas for the supercollider", World Scientific Publishing Co. 1988, ISBN 9971-5-473-1.

8. *Sec. 6.4 Elastic and Single Diffractive Scattering*, pages 245-247, Physics at Fermilab in the 1990's, World Scientific, 1990.

Figure Captions:

Fig. 1. That part of detector inside the beam pipe: trigger counters, scifi bundle, and fiber optics "light pipe".

Fig. 2. Scatter plot of y_p vs. y_p for run 758 before background subtraction. (b) Magnified view of the small-y corner of the plot.

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Fiber Optics Rod

Scintillating Counter

Scale in MM

8°

56

Light Pipe

Scintillating Fibers Bundle

95 Dia.

60

Scintillating Counter

Fig. 2

(b)

10 mm

2.5

5

2.5

5

10

Y_P (mm From Beam)

24

20

16

12

8

4

0

0   4   8   12   16   20   24

$Y_{\bar{P}}$ (mm from Beam)

(a)